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No. 346

BEHM ACOUSTIC SOUNDER FOR AIRCRAFT

From "Flugsport," November 11, 1925

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TECHNICAL MEMORANDUM NO. 346.

BEHM ACOUSTIC SOUNDER FOR AIRCRAFT.*

The Behm acoustic sounder for aircraft enables the non-barometric determination of the altitude by night or fog and therefore promises to prove of great importance in safeguarding air traffic. Since the beginning of aviation, the only altimeter has been the barometer, whose level falls only one millimeter for each eleven-meter increase in altitude and lags behind on account of the elastic reaction. In landing, therefore, the barometer generally indicates an altitude somewhat greater than the true altitude.

In fog or on a dark night or even by day, over extensive plains or snow-fields and especially over water, it is sometimes impossible to determine the height above the land or water. It is often rendered still more difficult in winter by fog and snow-storms and low-lying clouds, which necessitate flying at low and consequently dangerous altitudes. The visual estimation of the height is then so inaccurate as to give no conception of the actual altitude of flight. Any estimate of distance requires stereoscopic vision, which ceases completely, however, as soon as the images formed on the retina show no diversity. This is the case over broad level tracts of any kind, like still water, snow, ice and level land, when

* From "Flugsport," November 11, 1925, pp. 441-444.

viewed from above. Alighting on smooth water is especially difficult in such weather and even in bright sunlight.

The barometer indicates only the altitude above sea-level, whereby the actual barometer reading at sea-level must naturally be known. On long flights, therefore, the readings of the barometric altimeter often become unreliable due to sudden changes in the weather. The greatest objection to the use of the barometer is, however, that it does not give the actual height above the land, which is specially important when flying over mountains.

In forced landings, the safety of an airplane and its occupants depends largely on an exact knowledge of the distance above the ground during the whole landing time. This fact has been unfortunately demonstrated in numerous accidents. The necessity of night flying, arising from the development and extension of air traffic, requires an altimeter which will correctly indicate the height above the ground under all circumstances and especially in thick weather, such as fog, rain or snow.

For the solution of this problem, we have to thank the Kiel physicist, Alexander Behm, who is already known for his acoustic sounder for determining even the greatest ocean depths, which signifies a real revolution for oceanography. The Behm air-sounder, the first non-barometric altimeter, functions according to the same acoustic principle as his water-sounder. The sound waves of a sounding shot or tone pass from the airship

or airplane to the ground and return as an echo. The time elapsed is accurately and automatically measured to within 0.0001 second and thus gives accurately and instantly the distance from the ground.

The practical execution of such altitude measurements, for which Behm introduced the term "Luftlotung" (air-sounding), was demonstrated by him on the airship Z.R.III (Los Angeles). During the test flights of this airship, Behm made very successful soundings at an altitude of 200 m (656 ft.) and a flight speed of 100 km (62 miles) an hour.

In the meanwhile, Behm developed a special device for airplanes, which was first tested in September, 1925, at the D.V.L. ("Deutsche Versuchsanstalt für Luftfahrt"), Berlin-Adlershof. These tests also confirmed the practical solution of the problem. They were reported by Behm, September 10, 1925, in a lecture before the W.G.L. ("Wissenschaftliche Gesellschaft für Luftfahrt"), in Munich. At the same time he demonstrated, by experiments in the auditorium of the Physical Institute of the Munich Technical High School, how accurately such measurements can be made in the air. With the new Behm sounder for aircraft it is possible to determine the flight altitude over land or water, from a high altitude down to zero, with an error of not over 10 cm (4 in.) for low altitudes.

Since the greatest accuracy is required at the moment of landing, the effect of temperature on the velocity of sound is

negligible. An error of 5% at an altitude of 1 m (3.28 ft.) means an absolute error of only 5 cm (2 in.). Fig. 1 shows the new device installed on an airplane ready for the first experiment.

On the front side of the instrument there is an altitude scale from 0 to 60 m (nearly 200 ft.). On this scale there is visible below the zero line, after turning on the switch lever G at the right side of the housing, a point of light, which is set in motion at the instant of giving the sounding signal and appears for a brief interval as a line of light parallel to the scale and then, on the arrival of the echo, is suddenly deflected perpendicularly to its original direction. Fig. 2 shows several such records. Distances can be measured, by means of the echo, to within about 10 cm (4 in.) more or less, according to the size of the scale. After recording the arrival of the echo, the light point returns, invisible to the eye, to its original position, where it remains until a new signal forces it to record the echo, since this apparatus functions with perfect acoustic automatism. The Behm air-sounder automatically makes a sounding every half-second. Fig. 3 shows the sending and receiving apparatus as employed in the test flights. A new sender and receiver have since been constructed on the basis of the tests made and are installed entirely inside the airplane. The indicator has been given a small convenient form, which harmonizes with the other airplane instruments.

Regarding the first experiments, on August 20-26, 1925, the D.V.L. reports that the echo records were perfectly clear in gliding flight with the engine strongly throttled and that the gradual diminution in the echo deflections on the scale coincide with the personal observation of the altitude in gliding flight.

Concerning the experiments of September 29 to October 5, 1925, it was reported that the indicator was calibrated on the ground. The wall of an airplane hangar was utilized as a sound reflector. The measuring range was between 0 and 60 m (about 200 ft.). The real tests were carried out at this altitude and in gliding flight at an engine speed of 800-900 R.P.M. Some of the tests were made with the engine stopped. A few tests under full engine speed (which were, however, of secondary importance) gave satisfactory results.

The flight records corresponded perfectly to the laboratory records. The readability of the instrument is increased by giving the sounding signals at shorter intervals. The downward trend of the deflection of the light-pointer with increased altitude was perfectly apparent. The instrument readings compared favorably with the personal determinations.

The long-cherished wish of aviators for a reliable non-barometric altimeter for very low flight altitudes seems therefore to have been fulfilled by the Behm air-sounder.

Translation by Dwight M. Miner,
National Advisory Committee for Aeronautics.

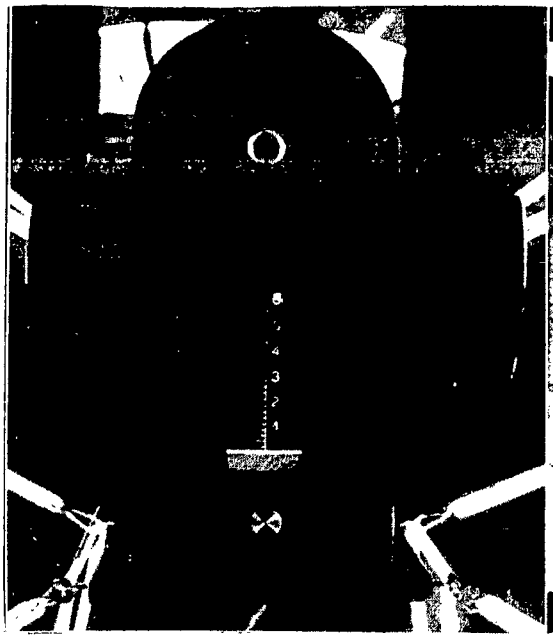

Fig.1 Behm air-sounder on airplane.

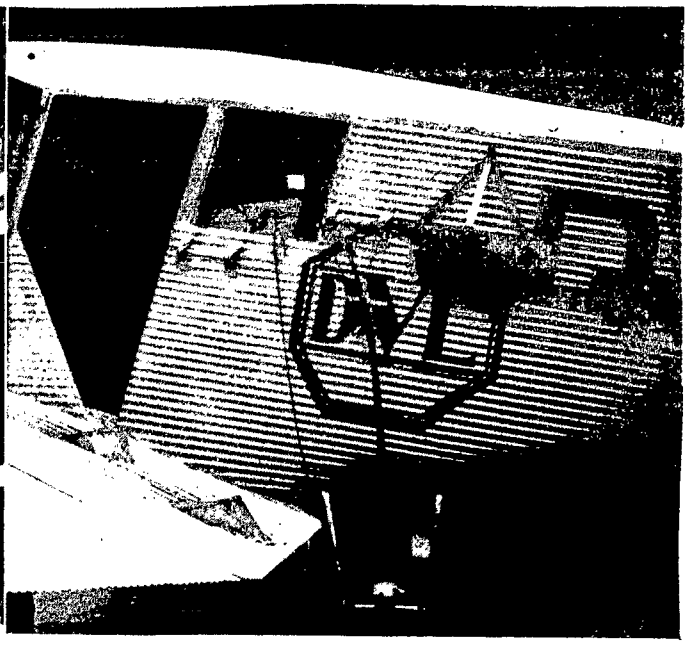

Fig.3 Behm sending and receiving apparatus.

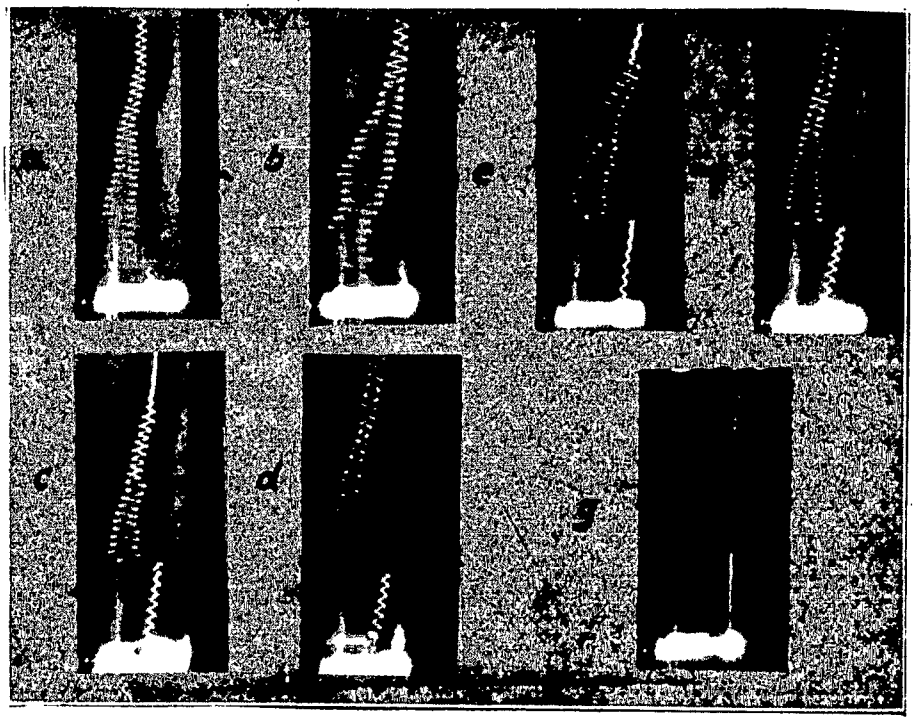

Fig.2 Behm sounder records.

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